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Total Number of Pages in This Submission 19 + 4 refs.

Application Number	09/042,681
Filing Date	March 12, 1998
First Named Inventor	Akiko Ishida, et al.
Art Unit	1746
Examiner Name	Jonathan Crepeau
Attorney Docket No.	MAT-5870

ENCLOSURES *(Check all that apply)*

- [x] Fee Transmittal Form
  - [x] Fee Attached
- [ ] Amendment/Reply
  - [ ] After Final
  - [ ] Affidavits/Declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [ ] Response to Missing Parts/ Incomplete Application
  - [ ] Response to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation, Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
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- [ ] After Allowance Communication to Group
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Signature	Lawrence E Ashery		
Printed Name	Lawrence E. Ashery		
Date	November 15, 2004	*Registration No.*	34,515

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FEE TRANSMITTAL for FY 2004

Effective 10/01/2003. Patent fees are subject to annual revision.

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 340.00

Complete if Known	
Application Number	09/042,681
Filing Date	March 12, 1998
First Named Inventor	Akiko ISHIDA, et al.
Examiner Name	Jonathan Crepeau
Art Unit	1746
Attorney Docket No.	MAT-5870

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FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1001	790	2001	395	Utility filing fee	
1002	350	2002	175	Design filing fee	
1003	550	2003	275	Plant filing fee	
1004	790	2004	395	Reissue filing fee	
1005	160	2005	80	Provisional filling fee	

SUBTOTAL (1) ($) 0

2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

			Extra Claims		Fee from below		Fee Paid
Total Claims		-20** =		X	18.	=	0
Independent Claims		-5** =		X	88.	=	0
Multiple Dependent				X	300.	=	0

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	88	2201	44	Independent claims in excess of 3
1203	300	2203	150	Multiple dependent claim, if not paid
1204	88	2204	44	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0.

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

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1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet.	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for *ex parte* reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	430	2252	215	Extension for reply within second month	
1253	980	2253	490	Extension for reply within third month	
1254	1,530	2254	765	Extension for reply within fourth month	
1255	2,080	2255	1,040	Extension for reply within fifth month	
1401	340	2401	170	Notice of Appeal	
1402	340	2402	170	Filing a brief in support of an appeal	340.
1403	300	2403	150	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive – unavoidable	
1453	1,370	2453	685	Petition to revive – unintentional	
1501	1,370	2501	685	Utility issue & publication fees (or reissue)	
1502	490	2502	245	Design issue fee	
1503	660	2503	330	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	790	2809	395	Filing a submission after final rejection (37 CFR § 1.129(a))	
1810	790	2810	395	For each additional invention to be examined (37 CFR § 1.129(b))	
1801	790	2801	395	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify))

*Reduced by Basic Filing Fee Paid SUBTOTAL (3) ($) 340.

SUBMITTED BY				Complete *(if applicable)*	
Name (Print/Type)	Lawrence E. Ashery	*Registration No. (Attorney/Agent)*	34,515	*Telephone*	(610) 407-0700
Signature	Lawrence E Ashery			*Date*	November 15, 2004

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appln. No:	09/042,681
Applicants:	Akiko Ishida et al.
Filed:	March 12, 1998
Title:	LITHIUM SECONDARY BATTERY
TC/A.U.:	1746
Examiner:	Jonathan Crepeau
Confirmation No.:	5427
Notice of Appeal Filed:	September 13, 2004
Docket No.:	MAT-5870

APPEAL BRIEF

Mail Stop Appeal Brief-Patents
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SIR:

In response to the Official Action dated August 17, 2004, Applicants are submitting this Appeal Brief for the above-identified application.

I. REAL PARTY IN INTEREST

The Real Party In Interest in this matter is Matsushita Electric Industrial Co., Ltd.

II. RELATED APPEALS AND INTERFERENCES

There are no other appeals or interferences known to Appellants, the Appellants legal representative, or Assignee which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

Claims 1-21, 23, 24, 26-32, 34 and 35 are canceled. Claims 22, 25, 33 and 36-28 are pending. Claims 22, 25, 33 and 36-38, all the pending claims, have been appealed.

IV. STATUS OF AMENDMENTS

The present application is under final rejection. All previous amendments have been entered. There are no pending unentered amendments.

V. SUMMARY OF CLAIMED SUBJECT MATTER

Independent claim 22 and dependent claims 25, 33, and 36-38, directly or indirectly dependent thereon, are appealed.

Independent claim 22 is drawn to a non-aqueous lithium secondary battery. The battery is described on page 4, line 97-101; page 7, line 166, to page 8, line 189; page 15, line 396, to page 17, line 452; original claims 13-15; and in Figure 7.

The battery comprises a positive electrode, a negative electrode, a microporous polymer film separator between the electrodes, and a nonaqueous electrolyte solution. Page 4, lines 97-101; Figure 7, described on page 15, line 399, to page 16, line 423; and original claim 13. The positive electrode comprises a lithium transition metal compound oxide. Original claim 13. The negative electrode, which is negative during discharging of the battery, comprises an active substance that occludes and releases lithium ions. Original claim 13. The nonaqueous electrolyte solution comprises a nonaqueous solvent and a lithium salt, which is $LiPF_6$, dissolved therein. Page 17, lines 435-438.

The negative electrode also comprises 5 to 20 parts by weight of ceramic particles in 100 parts by weight of the active substance that occludes and releases lithium ions. Page 7, lines 181-182; original claim 15, and page 17, lines 443-445. The ceramic particles are not related to the charge and discharge reactions of the battery. Page 4, lines 97-101; and original claim 13. The ceramic particles are aluminum oxide (Al_2O_3) particles, and the particle size of the particles is 1 micron or less. Page 17, lines 449-452.

Dependent claim 25 is drawn to a battery in which the lithium transition metal compound oxide is $LiCoO_2$. Page 16, line 413, and page 17, lines 435-438. Dependent claims 33 and 36 are drawn to a battery in which the content of ceramic particles is between 5 and 10 parts by weight. Page 8, lines 188-189; and page 9, lines 443-445. Dependent claims 37 and 38 are drawn to a battery in which the active substance that occludes and releases lithium ions is graphite, and the nonaqueous solvent comprises ethylene carbonate. Page 16, line 404; and page 17, lines 435-438.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

Claims 22, 25, 33 and 36-38 stand rejected under 35 U.S.C. § 102(b) as anticipated by the JAPIO English language Abstract and the computer generated English language translation of the claims and specification of Japanese published patent application JP H08-298121.

VII. ARGUMENT

A. Summary of the Argument

There are at least two differences between claim 22, the only independent claim on appeal, and the disclosure of JP H08-298121:

1. Claim 22 recites ceramic particles that are aluminum oxide particles. JP H08-298121 discloses particles of a carbon/ceramic composite material.

2. The aluminum oxide particles recited by claim 22 are inherently non-conductive. JP H08-298121 discloses conductive particles.

A single difference is enough to overcome the Examiner's assertion that the claim is anticipated. Therefore, the examiner's rejection of claims 22, 25, 33 and 36-38 as

anticipated by JP 8-298121 should be reversed.

B. Issue

All the appealed claims stand rejected under 35 U.S.C. § 102(b) as anticipated by the JAPIO English language Abstract and the computer generated English language translation of Japanese published patent application JP H08-298121 (collectively " JP 8-298121"). This is the only rejection; there are no other rejections and no other applied references. The only issue is whether the applied reference discloses all the limitations recited in the appealed claims.

C. Legal Standard

> A person shall be entitled to a patent unless . . .
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States . . . .
>
> 35 USC 102(b).

Anticipation requires that each and every limitation of the claim be disclosed, either expressly or under principles of inherency, in a single prior art reference. *In re Robertson*, 49 USPQ2d 1949, 1950-51 (Fed. Cir. 1999). Absence from the reference of any claimed limitation negates anticipation. *Rowe v. Dror*, 42 USPQ2d 1550, 1553 (Fed. Cir. 1997). Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient. *Rapoport v. Dement*, 59 USPQ2d 1215, 1222 (Fed. Cir. 2001).

D. Differences between the Appealed Claims and the Applied Reference

In the following discussion, reference will be made to the JAPIO English language Abstract and the computer generated English language translation of the claims and specification of JP 8-298121.

In JP 8-298121 particles of a conductive carbon/ceramic composite material are added to the positive electrode and/or the negative electrode of a nonaqueous secondary battery. Referring to the JAPIO abstract, JP 8-298121 discloses a nonaqueous secondary battery constituted of a positive electrode material, a negative electrode material, and a nonaqueous electrolyte containing a light metal salt. JP 8-298121, Abstract, lines 1-2. The battery is characterized by addition of a specific material as a conductive agent to a positive electrode and/or a negative electrode mixture. *Id.*, lines 3-4 (emphasis added). One of more carbon/ceramic ceramic composite materials preferably constituted of carbon and one or more of a carbide, a boride, an oxide, and a nitride are contained in a conductive agent for a positive electrode and/or a negative electrode mixture. *Id.*, lines 5-7 (emphasis added). Oxides include oxides of one or more of aluminum, silicon, magnesium, and zirconium. *Id.*, line 8.

Referring to the machine generated English language translation of JP 8-298121, claim 1 recites a battery characterized by including a kind of carbon/ceramic composite material at least as an electric conduction agent of a mixture. JP 8-298121, claim 1 (emphasis added).

Other disclosures in JP 8-298121 include the following:

> As for the average grain size of the electric conduction agent which consists of carbon/ceramic composite material of the invention, it is desirable

> that it is 0.1 to 10 micrometers.

Id., ¶ [0009], lines 11-12 (emphasis added0.

> Like this invention, if carbon/ceramic composite material is used as a kind of electric conduction agent at least, the non-water rechargeable battery with which the charge-and-discharge cycle of 40 degrees C has been improved notably can be obtained.

Id., ¶ [0058], lines 1-3 (emphasis added).

Claim 22, the only independent claim appealed, recites, among other limitations, a negative electrode material that comprises "ceramic particles," and "the ceramic particles are Al_2O_3 particles".

Ceramics are inherently non-conductive, a fact well known to those skilled in the art.

> In general, ceramics are hard, brittle, electrical and thermal insulators, require high-temperature processing, and are formed from powders.

McGraw-Hill Concise Encyclopedia of Science and Technology, McGraw-Hill, New York, 1984, "Ceramics," p. 319, right hand column, lines 1-4 (emphasis added)[1].

> Properties that make ceramic products desirable in electrical applications are high resistivity, high dielectric strength, low dielectric loss factor, high dielectric constant, and controllable magnetic properties.

Id., lines 47-50 (emphasis added).

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[1] A copy of this reference is attached as Evidence 1.

Aluminum oxide is a ceramic material. Specification, page 7, lines 173-174. Aluminum oxide is non-conductive, a fact well known to those skilled in the art. For example, The Merck Index, Merck & Co., Whitehouse Station, N.J., 13th Ed., 2001, p. 63, entry for "Aluminum Oxide"[2] discloses that aluminum oxide is an "electrical insulator" Webster's II New College Dictionary, Houghton Mifflin Company, Boston, 1995, p. 33-34, entry for "Alumina,"[3] discloses the alumina (aluminum oxide) is used to produce electrical insulation. Technical information available on the Internet from the Accuratus Corporation,[4] a supplier of aluminum oxide, indicates that aluminum oxide is used in high temperature electrical insulators and that it has a volume resistively of greater than 10^{14} ohm-cm.

As discussed above JP 8-298121 discloses addition of particles of a conductive carbon/ceramic composite material. Therefore, there are at least two differences between claim 22 and the disclosure of JP 8-298121.

1. Claim 22 recites ceramic particles that are aluminum oxide particles. JP 8-298121 discloses particles of a conductive carbon/ceramic composite material.

2. The aluminum oxide particles recited by claim 22 are inherently non-conductive. JP 8-298121 discloses conductive particles.

A single difference is enough to rebut the Examiner's assertion that the claim is anticipated. Therefore, the examiner's rejection of claim 22 as anticipated by JP 8-298121 should be reversed. Claims 25, 33 and 36-38 are allowable as claims dependent on an allowed claim.

---

[2] A copy of this reference is attached as Evidence 2.
[3] A copy of this reference is attached as Evidence 3.
[4] A copy of this reference is attached as Evidence 4.

E. Response to the Examiner's Arguments

The Examiner has offered the following arguments in response to the differences pointed out above.

Difference 1.

Claim 22 recites ceramic particles that are aluminum oxide particles. JP 8-298121 discloses particles of a conductive carbon/ceramic composite material.

The Examiner argues that the claims as currently drafted merely require the presence of particles that contain aluminum oxide. That the claim language is open-ended and does not expressly exclude components other than aluminum oxide from being present in the particles. Advisory action mailed 08/17/2004, page 3, lines 6-9.

The Examiner's argument ignores the express language of the claims. Open ended claim language has not been used. Claim 22 recites "ceramic particles," not "particles comprising a ceramic." Claim 22 recites "the ceramic particles are Al_2O_3 particles," not "the particles comprising a ceramic are particles comprising Al_2O_3." The terms are clear and unambiguous. Appellants submit that the plain meaning of the terms "ceramic particles" and "Al_2O_3 particles," as understood by those skilled in the art, is exactly what they say, "ceramic particles" and "Al_2O_3 particles," not "particles comprising a ceramic" and "particles comprising Al_2O_3."

Further, claims are interpreted as they would be by one skilled in the art reading the claim in light of the specification. *Orthokinetics, Inc. v. Safety Travel Chairs, Inc.*, 1 USPQ2d. 1081, 1088 (Fed. Cir. 1986). If necessary, reference can be made to the specification. As the terms are used throughout the specification, there is never any suggestion that the particles contain anything but a ceramic or aluminum oxide. *See*, for

example, page 7, lines 173-180; page 15, lines 396-398; page 17, lines 440-445; and 447-452. In Example 8, page 15, lines 396-398, the aluminum oxide particles are also described as alumina particles, indicating no other materials are present.

For these reasons, the Examiner's interpretation of the terms "ceramic particles" and "Al_2O_3 particles" cannot be affirmed, and the Examiner's rejection of claims 22, 25, 33 and 36-38 stand as anticipated by JP 8-298121 should be reversed.

In an earlier Office action, the Examiner also argued that the claim language was open ended with respect to the negative electrode (the negative electrode comprises ceramic particles) (emphasis Examiner's). Office action of May 20, 2004, page 3, lines 17-19. Although this statement is true, it is irrelevant to the instant issue. The term comprises makes the definition of the electrode open-ended. It does not make the term "ceramic particles" open ended.

The issue is what the claims recite viz. a viz. what the reference discloses. JP 8-298121 does not disclose ceramic particles. It discloses conductive particles of carbon/ceramic composite materials. The open ended comprising term in claim 22 would permit particles of conductive carbon/ceramic composite materials to be present in the negative electrode, in addition to the ceramic particles that are expressly recited in the claim and not disclosed by JP 8-298121. The fact that the particles disclosed by JP 8-298121 could be present in the electrode of the battery recited by claim 22 does not change the fact that the particles recited by claim 22 are not disclosed by JP 8-298121. For this additional reason the Examiner's rejection of claims 22, 25, 33 and 36-38 stand as anticipated by JP 8-298121 should be reversed.

Difference 2.

The aluminum oxide particles recited by claim 22 are non-conductive. JP 8-298121 discloses conductive particles.

The Examiner argues that the instant claims do not recite that the ceramic particles are non-conductive. Therefore, conductivity is not relevant to the patentability of the claims. Advisory action mailed 08/17/2004, page 3, lines 2-4.

Claim 22 recites both the "ceramic particles" and the "Al_2O_3 particles" limitations. Appellants position, as discussed above, it that both ceramics and Al_2O_3 are inherently non-conductive, a fact well known to those skilled in the art. Thus, recitation of "non-conductive ceramic particles" and/or "non-conductive Al_2O_3 particles" is both redundant and unnecessary.

In support of this position, appellants have placed on the record citations from three well known and generally accepted references, the McGraw-Hill Concise Encyclopedia of Science and Technology (Evidence 1), The Merck Index (Evidence 2), and Webster's II New College Dictionary (Evidence 3), as well as technical information from a supplier of aluminum oxide (Evidence 4). The Examiner has not provided any evidence to support his position. Therefore, his position is not supported by the record and can not be affirmed. *See*, *In re Lee*, 61 USPQ 1430 (Fed. Cir. 2002) (agency must make record to support its decisions); *see also*, *In re Wagner*, 152 USPQ 552, 559 (CCPA 1967) (subjective opinions are of little weight against contrary evidence).

F. Conclusion

There are at least two differences between claim 22, the only independent claim on appeal, and the disclosure of JP 8-298121. A single difference is enough to overcome the

Examiner's assertion that the claim is anticipated.

Therefore, the examiner's rejection of claim 22, and the claims dependent thereon, as anticipated by JP 8-298121 should be reversed, and such action is earnestly solicited.

Respectfully submitted,

RatnerPrestia

Lawrence E. Ashery, Reg. No. 34,515
Bruce M. Monroe, Reg. No. 33,602
Attorneys for Appellants

LEA/mjc

Attachment: Pending Claims

Dated: November 15, 2004

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The Commissioner for Patents is hereby authorized to charge payment to Deposit Account No. 18-0350 of any fees associated with this communication.

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VIII. CLAIMS APPENDIX

1.-21. (Cancelled)

22. (Previously Presented) A non-aqueous lithium ion secondary battery comprising:

a positive electrode comprising a lithium transition metal compound oxide;

a negative electrode which is negative during discharging of the battery, the negative electrode comprising an active substance that occludes and releases lithium ions;

a microporous polymer film separator between the positive electrode and the negative electrode; and

a nonaqueous electrolyte solution comprising a nonaqueous solvent and a lithium salt dissolved therein;

wherein:

the negative electrode comprises ceramic particles not relating to the charge and discharge reactions of the battery;

the negative electrode comprises 5 to 20 parts by weight of the ceramic particles in 100 parts by weight of the active substance;

the ceramic particles are Al_2O_3 particles;

the lithium salt is $LiPF_6$; and

the particle size of the ceramic particles is 1 micron or less.

23.- 24. (Cancelled)

25. (Previously Presented) The battery of claim 22 in which the lithium transition metal compound oxide is $LiCoO_2$.

26.-32. (Cancelled)

33. (Previously Presented) A lithium polymer secondary battery according to claim 38, wherein the content of said ceramic particles is between 5 and 10 parts by weight.

34.-35. (Cancelled)

36. (Previously Presented) A lithium polymer secondary battery according to claim 22, wherein the content of said ceramic particles is between 5 and 10 parts by weight.

37. (Previously Presented) A lithium polymer secondary battery according to claim 22, wherein the active substance that occludes and releases lithium ions is graphite, and the nonaqueous solvent comprises ethylene carbonate.

38. (Previously Presented) A lithium polymer secondary battery according to claim 37, wherein the nonaqueous solvent is a mixture of ethylene carbonate and ethyl methyl carbonate.

IX. EVIDENCE APPENDIX

1. McGraw-Hill Concise Encyclopedia of Science and Technology, McGraw-Hill, New York, 1984, "Ceramics," p. 319.

2. The Merck Index, Merck & Co., Whitehouse Station, N.J., 13th Ed., 2001, p. 63.

3. Webster's II New College Dictionary, Houghton Mifflin Company, Boston, 1995, "Alumina," p. 33-34.

4. "Aluminum Oxide," technical information from the Accuratus Corporation website, http://www.accuratus.com/alumox.html.

X. RELATED PROCEEDINGS APPENDIX

None

McGraw-Hill CONCISE Encyclopedia of SCIENCE & TECHNOLOGY

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ward and surrounds the mouth and is subdivided into eight or more appendages which sometimes are contractile, and in all but *Nautilus* are provided with suckers. As a result of the forward movement of the foot, the digestive tract is U-shaped and the viscera form a hump contained within a fleshy mantle in which the gills are also suspended. Fins are found in widely divergent forms, but the main means of locomotion is the funnel, found beneath the head. During rapid movement, water enters the mantle cavity and is violently ejected through the funnel, the animal moving posteriorly from the force of the jet.

Cephalopods feed voraciously upon crustaceans and larval and adult fish, and cannibalistically upon their own kind. Food is obtained by darting out the tentacles or arms and seizing the prey with suckers or, in some squids, with the clawlike hooks.

Cephalopods are numerous in the sea, particularly in the bathypelagic regions, where they occur in vast shoals. They form the most important part of the diet of the sperm whales and are the sole food of many of the smaller toothed whales, as well as a major item of food for the larger pelagic fishes. They are eaten by humans and fished for in many parts of the world. They may represent one of the largest nearly untouched food resources in the sea. See AMMONOIDEA; DECAPODA (MOLLUSCA); DIBRANCHIA; NAUTILOIDEA; OCTOPODA; OCTOPUS; SQUID; TETRABRANCHIA. [G.L.V.]

Cepheids A class of brightness-variable stars whose prototype is the star Delta Cephei in the constellation Cepheus. While both bluer and redder stars also vary in their intrinsic light, the properties of these β Cephei, ZZ Ceti, RV Tauri, and Mira variables are much less understood than the yellow-color Cepheids. These yellow stars are known to be pulsating in radius by as much as 10% or more. Their light variations are due to their changing surface temperature. Larger yellow stars are intrinsically brighter because they have more surface area, and they have larger pulsation periods because they have a larger radius. See STAR; VARIABLE STAR.

The interest in these stars is twofold: If their intrinsic brightnesses can be inferred from their pulsation period, the brightnesses can be used as indicators of their distance from the Earth. The observed period and a calibrated period-luminosity relation is used to give an intrinsic brightness. The observed distance-dependent apparent brightness then gives the actual distance. The second, and more current, interest in Cepheids is that their pulsation properties reveal their masses and internal structure, which help in understanding how stars age. Thus, Cepheids and the related classes of yellow pulsating stars have been extremely useful in mapping the scale of the universe and in probing the details of stellar interiors. See STELLAR EVOLUTION. [A.N.Co.]

Ceractinomorpha A subclass of Demospongiae. Among the Ceractinomorpha, the genus *Halisarca*, lacking skeletal elements, is a primitive form. The larva of *Halisarca* is a diploblastula or parenchymella with an outer layer of flagellated cells and an inner mass of presumptive ectomesenchymal cells. The outer flagellated cells lose their flagella, migrate into the interior, and later differentiate into choanocytes. Other cell types characteristic of the adult sponge differentiate, and inhalant canals begin to form.

In form, ceractinomorph sponges vary from encrustations, thin or massive, to lobate and upright branching colonies. The shallow-water species tend to be more plastic in form than deep-water species, which usually exhibit little intraspecific variation in shape. See DEMOSPONGIAE; PORIFERA. [W.D.H.]

Ceramics The application of the findings of science and engineering to the production of useful products from the nonmetallic, inorganic materials. Ceramics are materials which cover a great range in both applications and time. In general, ceramics are hard, brittle, electrical and thermal insulators, require high-temperature processing, and are formed from powders. The major divisions of ceramic technology are similar in processing and in the properties of the materials. However, differences in applications and differences in the behavior of materials during processing require that diverse techniques be used. See CERMET; COMPOSITE MATERIALS; SINTERING.

It is convenient to divide ceramic products into two groups: those, such as pottery and brick, which are shaped or formed before high-temperature treatment, and those, such as glass and cement, which are shaped afterward. Only the first group is discussed in this article. See CEMENT; GLASS; MORTAR; PLASTER.

Structural clay is one of the oldest branches of ceramics and includes building brick, sewer pipe, and decorative ceramic block for walls. To form these products from raw clays, use is made of the plastic forming technique known as extrusion. Extrusion is carried out by forcing a stiff plastic mass through an opening or die in the form of the desired cross section; the continuous ribbon which emerges is cut to the desired lengths. Drying is carried out in conditions of controlled humidity and temperature which prevent the ware from cracking or warping. The dried material is hard and can be broken with hand pressure. After drying, the material is heat-treated to a temperature where the clay is broken up into less complicated molecular structural units. The resulting material is now held together by chemical bonds between glass and oxide compounds, resulting in a hard, brittle material which is resistant to corrosion. This process is known as vitrification. See CLAY.

There are two major divisions of whiteware: art ware and consumer ware (tableware, portable lamps, sanitary ware, and so on). To form these products, powders of clay, potter's flint, and feldspar are used. The clay, when sufficiently wet, imparts plasticity or workability to the body. The forming methods used for consumer whiteware production are slip casting and jiggering. Jiggering is a mechanization of the forming process of throwing clay by hand as done by the potter. For large items such as sanitary ware, artware, and portable lamps, slip casting is most often used. Slip casting of clays is done by pouring a water suspension of the body (a slip) into a plaster of paris mold of the desired shape. The porous plaster mold withdraws water from the slip, which results in a buildup of a layer of solid clay next to the mold. Once the materials have been formed into the desired shape, drying and firing are carried out. See POTTERY.

Properties that make ceramic products desirable in electrical applications are high resistivity, high dielectric strength, low dielectric loss factor, high dielectric constant, and controllable magnetic properties. The ceramic products used in the electrical industry include porcelains, glasses, steatites, cordierites, titanates, zirconates, carbides, oxides, and ferrites. Ceramic products are used in magnets, electronic tubes, condensers, resistors, transformers, amplifiers, memory devices, transducers, capacitors, and insulators. See FERRITE; PORCELAIN.

Ceramics known as refractories are products which thermally insulate the furnaces that produce steel, aluminum, and other metals. They also insulate the furnaces that produce the steam for the generation of electricity, as well as insulate fireplaces in the homes. The manufacture of refractories is one of the key industries in the United States. See REFRACTORY. [G.E.S.]

Cerargyrite A mineral with composition AgCl. Its structure is that of the isometric NaCl type, but well-formed cubic crystals are rare. The hardness is 2½ on Mohs scale and specific gravity 5.5. Cerargyrite is colorless to pearl-gray but darkens to violet-brown on exposure to light. It is perfectly sectile and

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21645-51-2] Aluminum
l alumina. AlH_3O_3; mol
1.54%. $Al(OH)_3$. Prepn
Chim. [12], 5, 106 (1950);
1. 44, 965f (1950); Gme-
3-132 (1934); Becher in
Chemistry, vol. 1, G.
:k, 2nd ed., 1963) pp 820-
1652-1654. Comparative
acids: F. W. Green, Jr. *et*
75). Clinical comparison
: binder in chronic renal
Med. J. 291, 623 (1985).
V. Nicklas, *Res. Immunol.*

amorphous powder. Prac-
ne aq solns or in HCl, H_2-
ence of some water. Forms
. Absorbs acids, CO_2.
ix; ALternaGEL; Aludyal;
acid. White, viscous sus-
ied gel.
exchanger; in chromatog-
medium; manuf glass, fire
oricating compositions, de-
antiperspirants, dentifrices.

hosphatemic.

oride. [1327-41-9] Basic
ilorohydroxide; aluminum
rol; Locron; Phosphonorm.
mula is $Al_2(OH)_5Cl.2H_2O$.
table Al salts: **FR 837862**
3. Farben.); H. Huehn, W.
sen, **US 2492085** (1949 to
: and physicochemical prop-
Pharm. Sci. 70, 758, 762
' and use in hyperphospha-
-Pharma), *C.A.* 99, 110747a

forming slightly turbid col-
of 15% aq soln ~4.3.

perphosphatemic.

phite. [7784-22-7] AlH_6O_6-
2.72%, O 43.25%, P 41.87%.
$OH)_3$ or a solution of an alu-
s acid or sodium hypophos-
2, 2945.
hout melting at ~220° with
y insol in water. Sol in warm
lilute or concd hydrochloric

iber finishes.

[7784-23-8] AlI_3; mol wt
on from aluminum and iodine:
i3); H. J. Becher in *Handbook*
ry vol. 1, G. Brauer, Ed. (Ac-
1963) p 814; Wilson, Worrall,

nercial grade yellowish- to
bp 382°; d^{17} 3.948. Fumes in
ation with water. *Keep tightly*
ol in carbon disulfide, alcohol,

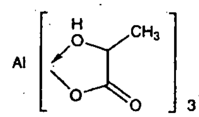
liquesc cryst powder. Sol in
ly closed.
ions.

346. Aluminum Isopropoxide. [555-31-7] 2-Propanol aluminum salt; aluminum isopropylate. $C_9H_{21}AlO_3$; mol wt 204.24. C 52.93%, H 10.36%, Al 13.21%, O 23.50%. $Al[OCH(CH_3)_2]_3$. Prepd from aluminum and isopropyl alcohol in the presence of mercuric chloride: Young *et al.*, *J. Am. Chem. Soc.* **58**, 100 (1936); by adding excess isopropyl alcohol to a benzene soln of $AlCl_3$ at 6°: Teichner, *Compt. Rend.* **237**, 810 (1953). Forms trimers and tetramers: Shiner *et al.*, *J. Am. Chem. Soc.* **85**, 2318 (1963); Oliver *et al.*, *J. Inorg. Nucl. Chem.* **31**, 1609 (1969); Worrall, *J. Chem. Ed.* **46**, 510 (1969). Toxicity: Smyth *et al.*, *Am. Ind. Hyg. Assoc. J.* **30**, 470 (1969). *Review:* Whitaker, *Advan. Chem. Series* **23**, 184-189 (1959).

Hygroscopic white solid, mp 119°. Solidifies rather slowly after distillation. bp_{10} 135°; $bp_{7.5}$ 131°; $bp_{5.5}$ 125.5°; $bp_{2.5}$ 113°; $bp_{1.5}$ 106°; $bp_{0.5}$ 94°. Sol in ethanol, isopropanol, benzene, toluene, chloroform, carbon tetrachloride, petroleum hydrocarbons. Decomposed by water. LD_{50} orally in rats: 11.3 g/kg (Smyth).

USE: Meerwein-Ponndorf reactions; alcoholysis and ester exchange; synthesis of higher alkoxides, chelates, and acylates; formation of aluminum soaps, formulation of paints; waterproofing finishes for textiles.

347. Aluminum Lactate. [18917-91-4] Aluctyl. $C_9H_{15}AlO_9$; mol wt 294.19. C 36.74%, H 5.14%, Al 9.17%, O 48.95%. Prepn from lactic acid and aluminum isopropoxide or aluminum chloride: Rai *et al.*, *J. Prakt. Chem.* **20**, 105 (1963); from lactic acid and aluminum foil: Jones, Cluskey, *Cereal Chem.* **40**, 589 (1963).



Powder. Freely sol in water.

USE: In foam fire extinguishers; in dental-impression materials.

THERAP CAT: Antiseptic.

348. Aluminum Lithium Hydride. [16853-85-3] Lithium tetrahydroaluminate; lithium aluminum hydride; lithium aluminohydride; lithium alanate. AlH_4Li; mol wt 37.96. Al 71.08%, H 10.62%, Li 18.29%. $LiAlH_4$. Prepd by treating lithium hydride with an ether soln of $AlCl_3$: Finholt, *et al.*, *J. Am. Chem. Soc.* **69**, 1199 (1947). Crystal structure: Sklar, Post, *Inorg. Chem.* **6**, 669 (1967). Review of chemistry: J. S. Pizey, *Synthetic Reagents,* **Vol. 1** (John Wiley, New York, 1974) pp 101-294.

Microcrystalline white powder when pure; gray when aluminum impurity present. Monoclinic crystals. d 0.92. Stable in dry air at room temperature, decomp above 125°, slowly loses hydrogen at 120°, decomp in moist air, may ignite on grinding in air. Soly (parts/100 parts solvent): 30 (ether); 13 (tetrahydrofuran); 10 (dimethylcellosolve); 2 (dibutyl ether); 0.1 (dioxane). Reacts rapidly with water and alcohols; reduces aldehydes, ketones, acid chlorides and esters to alcohols; nitriles to amines; aromatic nitro compounds to azo compounds. Does not attack olefinic double bonds unless they are conjugated with a phenyl group and a carbonyl or nitrile group.

USE: Reducing agent; in preparation of other hydrides.

349. Aluminum Magnesium Silicate. [12511-31-8] Magnesium aluminum silicate. $Al_2MgO_8Si_2$; mol wt 262.43. Al 20.56%, Mg 9.26%, O 48.77%, Si 21.40%. $MgAl_2(SiO_4)_2$. Occurs in nature in the minerals: ***colerainite, leuchtenbergite, pyrope, saponite, sapphirine, sheridanite, zebedassite.*** Prepn: **GB 834517** (1960 to Fuji Chem.)

Hydrate. Ervasil.

USE: As suspending agent, thickening agent.

THERAP CAT: Antacid.

350. Aluminum Nicotinate. Nicalex. Pharmaceutical composition consisting of aluminum hydroxydinicotinate and nicotinic acid. Manufacturing process: J. P. Miale, **US 2970082** (1961 to Walker Labs.). Prepn, properties and clinical studies: *idem, Curr. Ther. Res.* **7**, 392 (1965). Clinical trial in hypercholesterolemia: E. S. McCabe, *Del. Med. J.* **38**, 49 (1966).

White, amorphous powder with very slight acidulous taste. Insol in water, alchol. Sol in diluted mineral acids.

THERAP CAT: Has been used as antihyperlipoproteinemic.

351. Aluminum Nitrate. [13473-90-0] AlN_3O_9; mol wt 213.00. Al 12.67%, N 19.73%, O 67.60%. $Al(NO_3)_3$. Occurs in several states of hydration of which the nonahydrate is the most stable. Prepn: *Gmelin's, Aluminum* (8th ed.) **35B**, p 149-152 (1934). Toxicity data: Smyth *et al.*, *Am. Ind. Hyg. Assoc. J.* **30**, 470 (1969).

Nonahydrate. Deliquesc crystals; mp 73°; dec at 135°. Very sol in water, alc; very slightly sol in acetone. Almost insol in ethyl acetate and pyridine. The aq soln is acid. *Keep well closed.* LD_{50} orally in rats: 4.28 g/kg (Smyth).

USE: Tanning leather; antiperspirant; corrosion inhibitor; extraction of uranium; nitrating agent.

352. Aluminum Nitride. [24304-00-5] AlN; mol wt 40.99. Al 65.82%, N 34.17%. Prepd commercially by heating bauxite and coal in a stream of nitrogen. Laboratory prepn from powdered aluminum metal: Becher in *Handbook of Preparative Inorganic Chemistry* **Vol. 1**, G. Brauer, Ed. (Academic Press, New York, 2nd ed., 1963) p 827.

Orthorhombic or hexagonal, bluish-white crystals. In moist air, odor of ammonia. d_4^{25} 3.05. Hardness no: 9 to 10 on Mohs' scale. mp 2150-2200° at 4.3 atm. Spec heat at 0°: 0.180 cal/g/°C; at 100°: 0.207 cal/g/°C; at 500°: 0.313 cal/g/°C. Heat of formation: −74 kcal/mol. Decomposed by water into $Al(OH)_3$ and NH_3.

USE: In semiconductor electronics; in steel manuf.

353. Aluminum Oleate. [688-37-9] 9-Octadecenoic acid aluminum salt; oleic acid aluminum salt. $C_{54}H_{99}AlO_6$; mol wt 871.34. C 74.43%, H 11.45%, Al 3.10%, O 11.02%. $[CH_3(CH_2)_7CH{=}CH(CH_2)_7COO]_3Al$. Prepd from freshly pptd $Al_2(OH)_6$ and oleic acid: Stich, *Pharm. Zentralhalle* **63**, 261 (1922), *C.A.* **16**, 2755 (1922).

Yellowish, viscid mass. Practically insol in water. Sol in alcohol, benzene, ether, oil turpentine.

USE: In oil or turpentine soln as lacquer for metals, as size, waterproofing agent, drier, for paints, high-pressure and high-temp greases for thickening lubricating oils.

354. Aluminum Oxalate. [814-87-9] $C_6Al_2O_{12}$; mol wt 318.02. C 22.66%, Al 16.97%, O 60.37%. $Al_2(C_2O_4)_3$. Prepn: **GB 348789** and **GB 348790** (both 1930 to I.G. Farben).

Hydrate. Powder. Practically insol in water, alc. Sol in mineral acids.

USE: Mordant in printing textiles, dyeing cotton.

355. Aluminum Oxide. [1344-28-1] Alumina. Al_2O_3; mol wt 101.96. Al 52.93%, O 47.08%. Occurs in nature as the minerals: ***bauxite, bayerite, boehmite, corundum, diaspore, gibbsite.*** Prepn and properties: *Mellor's* **vol. V**, 263-273 (1929); *Gmelin's, Aluminum* (8th ed.) **35B**, pp 7-98 (1934); Becher in *Handbook of Preparative Inorganic Chemistry* **vol. 1**, G. Brauer, Ed. (Academic Press, New York, 2nd ed., 1963) pp 822-823; Wagner, *ibid.* **vol. 2** (1965) pp 1660-1663. Use as column matrix in ion chromatography: W. Buchberger, K. Winsauer, *J. Chromatog.* **482**, 401 (1989); in HPLC: M. T. Kelly, M. R. Smyth, *J. Pharm. Biomed. Anal.* **7**, 1757 (1989). Clinical evaluation in hip replacement: L. Sedel *et al.*, *J. Bone Joint Surg. [Brit].* **72-B**, 658 (1990); of wear in hip replacement: L. P. Zichner, H.-G. Willert, *Clin. Ortho. Rel. Res.* **282**, 86 (1992). Review of properties, biocompatibility and clinical use: P. Boutin *et al.*, *J. Biomed. Mat. Res.* **22**, 1203-1232 (1988); of biocompatibility: P. S. Christel, *Clin. Ortho. Rel. Res.* **282**, 10-18 (1992).

Approximate characteristics of native aluminum oxide: White cryst powder. Very hard, about 8.8 on Moh's scale. An electrical insulator; electrical resistivity at 300° about 1.2×10^{13} ohms-cm. When heated above 800° it becomes insol in acid and specific gravity increases from 2.8 to 4.0. Insol in water. Very hygroscopic.

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This letter, called the "hard ign," is very rare in modern ussian. It indicates that the revious consonant remains ard even when followed by a ont vowel.
This letter, called the "soft ign," indicates that the previ- us consonant is palatalized ven when a front vowel does ot follow.

ic (-fə-mĕr′ĭk) *adj.* [ALPHA(BETIC) + NUMERIC(AL).] **1.** Consisting of alphabetic and numerical symbols. **2.** *Computer Sci.* Consisting of alphabetic and numerical symbols and of punctuation marks, mathematical symbols, and other traditional symbols.
alpha particle *n.* A positively charged composite particle, indistinguishable from a helium atom nucleus and having two protons and two neutrons.
alpha privative *n.* The Greek negative prefix *a-* which occurs as *an-* before vowels.
alpha ray *n.* A stream of alpha particles.
al·pha-re·cep·tor (ăl′fə-rĭ-sĕp′tər) *n.* A site in the autonomic nervous system in which excitatory responses occur when adrenergic agents, such as epinephrine, are released.
alpha rhythm *also* **alpha wave** *n.* The most frequent electroencephalographic waveform found in recordings of the electrical activity of the adult human brain, having a frequency of 8 to 13 hertz and occurring when a person is awake and relaxed.
al·pho·sis (ăl-fō′sĭs) *n.* [Gk. *alphos,* leprosy + -OSIS.] Abnormal lack of skin pigmentation, as in albinism.
al·pine (ăl′pīn′) *adj.* [Lat. *Alpinus* < *Alpes,* the Alps.] **1. Alpine.** Of, relating to, or typical of the Alps or their inhabitants. **2.** Of or relating to high mountains. **3.** *Biol.* Living or growing on mountains above the timberline. **4.** Designed for or concerned with mountaineering. **5. Alpine.** Of or relating to competitive downhill racing and slalom skiing events.
al·pin·ist *also* **Al·pin·ist** (ăl′pə-nĭst) *n.* A mountain climber : MOUNTAINEER. **—al′pin·ism** *n.*
al·read·y (ôl-rĕd′ē) *adv.* [ME *alredi* : *al,* all + *redi,* ready.] **1.** By this or a specified time : PREVIOUSLY. **2.** —Used as an intensive <Stop *already!*>
al·right (ôl-rīt′) *adv. Nonstandard.* All right.
Al·sa·tian (ăl-sā′shən) *adj.* Of or relating to Alsace, its inhabitants, or their culture. —*n.* **1.** A native or inhabitant of Alsace. **2.** *Chiefly Brit.* The German shepherd.
al·sike clover (ăl′sīk′) *n.* [After *Alsike,* Sweden.] A plant native to Eurasia, *Trifolium hybridum,* with compound leaves and pink or whitish flowers, widely grown for forage.
al·so (ôl′sō) *adv.* [ME < OE *ealswa* : *eall,* all + *swā,* so.] In addition : LIKEWISE. —*conj.* And in addition.
al·so-ran (ôl′sō-răn′) *n. Informal.* One that is defeated, as in a competition, election, or race.
alt (ălt) [Lat. *altus,* high.] *Mus.* —*adj.* Pitched in the first octave above the treble staff. —*n.* **1.** The first octave above the treble staff. **2.** A note or tone in the alt octave.
Al·ta·ic (ăl-tā′ĭk) *n.* [After the *Altai* Mountains.] A language family of Europe and Asia that includes the Turkic, Tungusic, and Mongolic subfamilies. —*adj.* **1.** Of or relating to the Altai Mountains. **2.** Of or relating to the Altaic language family.
Al·tair (ăl-tīr′, -târ′, ăl′tīr′, -târ′) *n.* [Ar. *al-ṭāir* < *al-nasr al-ṭāir,* the flying eagle.] A bright, double, variable star in the northern constellation Aquila.
al·tar (ôl′tər) *n.* [ME *auter* < OE *altar* < Lat. *altare.*] **1.** An elevated place or structure before which religious ceremonies may be enacted or on which sacrifices may be offered.. **2.** A table before which the divine offices are recited and on which the Eucharist is celebrated in Christian churches.
altar boy *n.* An attendant to an officiating member of the clergy in the performance of a liturgical service : ACOLYTE.
al·tar·piece (ôl′tər-pēs′) *n.* Artwork, as a painting or carving, placed above and behind an altar.
altar rail *n.* A railing in front of the altar that separates the chancel from the rest of the church.
altar stone *n. Rom. Cath. Ch.* A stone slab containing relics that is incorporated into an altar.
alt·az·i·muth (ăl-tăz′ə-məth) *n.* [ALT(ITUDE) + AZIMUTH.] A mounting for astronomical telescopes that permits both horizontal and vertical rotation.
al·ter (ôl′tər) *v.* **-tered, -ter·ing, -ters.** [ME *alteren* < Med. Lat. *alterare* < Lat. *alter,* other.] —*vt.* **1.** To make different : MODIFY. **2.** To adjust (a garment) for a better fit. **3.** *Informal.* To spay or castrate. —*vi.* To become modified.
al·ter·a·ble (ôl′tər-ə-bəl) *adj.* Capable of being changed. **—al′ter·a·bil′i·ty, al′ter·a·ble·ness** *n.* **—al′ter·a·bly** *adv.*
al·ter·a·tion (ôl′tə-rā′shən) *n.* **1.** The act or process of altering. **2.** The condition of being altered : MODIFICATION.
al·ter·a·tive (ôl′tə-rā′tĭv, -tər-ə-tĭv) *adj.* **1.** Tending to bring about alteration. **2.** *Med.* Tending to restore normal health. —*n. Med.* An alterative treatment or medication.
al·ter·cate (ôl′tər-kāt′) *vi.* **-cat·ed, -cat·ing, -cates.** [Lat. *altercari, altercat-,* to quarrel < *alter,* other.] To argue vehemently.
al·ter·ca·tion (ôl′tər-kā′shən) *n.* A vehement quarrel.
al·ter e·go (ôl′tər ē′gō) *n.* [Lat., other I.] **1.** Another aspect of one's personality. **2.** An intimate friend or constant companion.
al·ter·nate (ôl′tər-nāt′, ăl′-) *v.* **-nat·ed, -nat·ing, -nates.** [Lat. *alternare, alternat-* < *alternus,* by turns < *alter,* other.] —*vi.* **1.** To occur in successive turns <Day *alternates* with night.> **2.** To change from one state, action, or place to another regularly <*alternates* between pitcher and catcher> —*vt.* **1.** To perform by turns. **2.** To cause to interchange regularly. —*adj.* (-nĭt). **1.** Happening or following successively. **2.** Designating or relating to every other one of a series <*alternate* rows> **3.** In place of another : SUBSTITUTE <an *alternate* method> **4.** *Bot.* **a.** Growing at alternating intervals on either side of a stem. **b.** Arranged alternately between other parts, as stamens between petals. —*n.* (-nĭt). One acting in the place of another : SUBSTITUTE. **—al′ter·nate·ly** *adv.* **—al′ter·nate·ness** *n.*
alternate angle *n.* An angle on one side of a transversal that cuts two lines, having one of the intersected lines as a side.
alternating current *n.* An electric current that reverses direction in a circuit at regular intervals.
al·ter·na·tion (ôl′tər-nā′shən, ăl′-) *n.* Successive change from one thing to another and back again.
alternation of generations *n.* Metagenesis.
al·ter·na·tive (ôl-tûr′nə-tĭv, ăl-) *n.* **1.** Choice between two mutually exclusive possibilities or either of these possibilities. **2.** One of a number of things from which one must be chosen. —*adj.* **1.** Necessitating or allowing a choice between two or more than two things. **2.** Existing outside traditional or conventional institutions or systems <an *alternative* church> **—al·ter′na·tive·ly** *adv.*
alternative box *n.* An element in a flow chart that signifies a decision to be made.
alternative school *n.* A school that is nontraditional, esp. in educational ideals or methods of teaching.
al·ter·na·tor (ôl′tər-nā′tər, ăl′-) *n.* An electric generator that produces alternating current.
al·the·a *also* **al·thae·a** (ăl-thē′ə) *n.* [Lat., mallows < Gk. *althaia* < *althein,* to heal.] **1.** The rose of Sharon. **2.** A plant of the genus *Althaea,* which includes the hollyhock.
al·tho (ôl-thō′) *conj. var. of* ALTHOUGH.
alt·horn (ălt′hôrn′) *n.* [G. : *alt,* alto + *Horn,* horn.] An alto saxhorn.
al·though *also* **al·tho** (ôl-thō′) *conj.* [ME : *al,* all + *though,* though.] Even though <*Although* I was ill, I went to work.>
al·tim·e·ter (ăl-tĭm′ĭ-tər) *n.* [Lat. *altus,* high + -METER.] An apparatus for determining elevation, esp. an aneroid barometer used in aircraft that senses pressure changes caused by changes in altitude. **—al·tim′e·try** *n.*
al·ti·pla·no (äl′tĭ-plä′nō) *n.* [Am. Sp. : Lat. *altus,* high + Lat. *planum,* plain.] A high plateau.
al·ti·tude (ăl′tĭ-to͞od′, -tyo͞od′) *n.* [ME < Lat. *altitudo* < *altus,* high.] **1.** The elevation of an object above a reference level, esp. above sea level or above the earth's surface. **2.** *often* **altitudes.** A high area or location. **3.** *Astron.* The angular distance of a celestial object above the horizon. **4.** The perpendicular distance from the base of a geometric figure to the opposite vertex, parallel side, or parallel surface. **5.** A high rank or position. **—al′ti·tu′di·nal** (-to͞od′n-əl, -tyo͞od′-) *adj.*
altitude sickness *n.* Illness caused by an oxygen deficiency, as that encountered at high altitudes, and characterized by symptoms such as nausea, breathlessness, and nosebleed.
al·to (ăl′tō) *n., pl.* **-tos.** [Ital., high < Lat. *altus.*] *Mus.* **1.** A low female singing voice : CONTRALTO. **2.** A countertenor. **3.** The range between soprano and tenor. **4.** A singer whose voice is within the alto range. **5.** An instrument that produces sound within the alto range. **6.** A part written for an alto voice or instrument.
▲ ***word history:*** *Alto* in Italian means "high." It is applied to the lowest female singing voice because the range of the female alto is the same as that of the highest male singing voice, which was originally called the alto.
al·to·cu·mu·lus (ăl′tō-kyo͞o′myə-ləs) *n.* [Lat. *altus,* high + CUMULUS.] A formation of roundish, fleecy, white or gray clouds.
al·to·geth·er (ôl′tə-gĕth′ər) *adv.* [ME *al togeder* : *al,* all + *togeder,* together.] **1.** Completely : entirely <started a new life *altogether*> **2.** With all included or counted <*Altogether* a dozen gifts arrived.> **3.** On the whole <*Altogether,* I'm sorry I went.> —*n.* A whole. **—in the altogether.** *Informal.* Nude.
al·to-ri·lie·vo *also* **al·to-re·lie·vo** (äl′tō-rĭ-lē′vō, äl′tō-rĕl-yä′vō) *n., pl.* **al·to-re·lie·vos** *also* **al·to-ri·lie·vi** (äl′tō-rĕl-yā′vē) [Ital. *alto rilievo.*] High relief.
al·to·stra·tus (ăl′tō-strā′təs, -străt′əs) *n.* [Lat. *altus,* high + STRATUS.] An extended cloud formation of bluish or gray sheets or layers.
al·tri·cial (ăl-trĭsh′əl) *adj.* [< Lat. *altrix, altric-,* fem. of *altor,* nourisher < *alere,* to nourish.] Naked and helpless when hatched, as young pigeons.
al·tru·ism (ăl′tro͞o-ĭz′əm) *n.* [Fr. *altruisme,* prob. < Ital. *altrui,* someone else < Lat. *alter,* other.] Selfless regard or concern for the well-being of others. **—al′tru·ist** (-ĭst) *n.* **—al′tru·is′tic** *adj.* **—al′tru·is′ti·cal·ly** *adv.*
al·u·la (ăl′yə-lə) *n., pl.* **-lae** (-lē′) [NLat., dim. of Lat. *ala,* wing.] The feathers attached to the part of a bird's wing corresponding to the thumb. **—al′u·lar** (-lər) *adj.*
al·um (ăl′əm) *n.* [ME < OFr. < Lat. *alumen.*] Any of various double sulfates of a trivalent metal such as aluminum, chromium, or iron and a univalent metal such as potassium or sodium, esp. aluminum potassium sulfate, $AlK(SO_4)_2 \cdot 12H_2O$, widely used industrially as clarifiers, hardeners, and purifiers and medicinally as topical astringents and styptics.
a·lu·mi·na (ə-lo͞o′mə-nə) *n.* [NLat. < Lat. *alumen,* alum.] Any of

several forms of aluminum oxide, Al_2O_3, occurring naturally as corundum, in a hydrated form in bauxite, and with various impurities as ruby, sapphire, and emery, used in producing aluminum and in abrasives, refractories, ceramics, and electrical insulation.

a·lu·mi·nate (ə-lo͞o′mə-nāt′, -nĭt) *n.* A chemical compound having aluminum as part of a negative ion.

a·lu·mi·nif·er·ous (ə-lo͞o′mə-nĭf′ər-əs) *adj.* [Lat. *alumen, alumin-* + -FEROUS.] Having or yielding aluminum, alumina, or alum.

al·u·min·i·um (ăl′yə-mĭn′ē-əm) *n.* [NLat. < *alumina*, alumina.] *Chiefly Brit. var. of* ALUMINUM.

a·lu·mi·nize (ə-lo͞o′mə-nīz′) *vt.* **-nized, -niz·ing, -niz·es.** To cover or coat with aluminum or aluminum paint.

a·lu·mi·nous (ə-lo͞o′mə-nəs) *adj.* Of, relating to, or having aluminum or alum.

a·lu·mi·num (ə-lo͞o′mə-nəm) *n.* [ALUMIN(A) + -IUM.] *Symbol* **Al** A silvery-white, ductile metallic element used to form many hard, light, corrosion-resistant alloys; atomic number 13; atomic weight 26.98.

aluminum oxide *n.* Alumina.

aluminum paste *n.* Aluminum powder ground in oil, used in manufacturing aluminum paints.

aluminum sulfate *n.* A white crystalline compound, $Al_2(SO_4)_3$, used in papermaking, water purification, sanitation, and tanning.

a·lum·na (ə-lŭm′nə) *n., pl.* **-nae** (-nē′) [Lat., fem. of *alumnus*.] A woman graduate or former student of a school, college, or university.

a·lum·nus (ə-lŭm′nəs) *n., pl.* **-ni** (-nī′) [Lat., pupil < *alere*, to nourish.] A male graduate or former student of a school, college, or university. ***usage:*** *Alumni* is generally used to refer to both the alumni and alumnae of a coeducational institution.

al·um·root (ăl′əm-ro͞ot′, -ro͝ot′) *n.* **1.** A North American plant of the genus *Heuchera*, with small white, reddish, or green flower clusters and astringent roots. **2.** The wild geranium.

A·lun·dum (ə-lŭn′dəm). A trademark for a hard, artificial abrasive of fused alumina, used to make oilstones and grinding wheels.

al·u·nite (ăl′yə-nīt′) *n.* [Fr. < *alun*, alum < Lat. *alumen*.] A gray mineral, essentially $K_2Al_3(OH)_6(SO_4)_3$, used in alum and fertilizer.

al·ve·o·lar (ăl-vē′ə-lər) *adj.* [Fr. *alvéolaire* < *alvéole*, alveolus < Lat. *alveolus*.] **1.** Of or relating to an alveolus. **2.** *Anat.* **a.** Relating to the portion of the jaw containing the tooth sockets. **b.** Relating to the alveoli of the lungs. **3.** Formed with the tip of the tongue touching or near the upper alveoli, as the English sounds *t, d,* and *s.* —*n.* An alveolar sound. —**al·ve′o·lar·ly** *adv.*

al·ve·o·late (ăl-vē′ə-lĭt) *adj.* Honeycombed with alveoli. —**al·ve′o·la′tion** (-lā′shən) *n.*

al·ve·o·lus (ăl-vē′ə-ləs) *n., pl.* **-li** (-lī′) [Lat., small hollow, dim. of *alveus*, a hollow < *alvus*, belly.] **1.** A small pit or cavity, as an individual cell of a honeycomb. **2.** A tooth socket in the jawbone. **3.** An air sac of the lungs at the termination of a bronchiole.

al·ways (ôl′wāz, -wĭz, -wēz) *adv.* [ME *alwei* < OE *ealne weg*, all the way : *ealne*, accusative of *eall*, all + *weg*, way.] **1.** At every instance : CONSISTENTLY <*always* late> **2.** For all time <We will love them *always*.> **3.** At any time : at will <You can *always* leave if you're dissatisfied.>

a·lys·sum (ə-lĭs′əm) *n.* [NLat. *Alyssum*, genus name < Gk. *alusson*, a plant believed to cure rabies : *a-*, not + *lussa*, rabies.] **1.** A plant of the genus *Alyssum*, with dense yellow or white flower clusters. **2.** Sweet alyssum.

Alz·heim·er's disease (älts′hī-mərz, ălts′-) *n.* [After Alois *Alzheimer* (1864–1915).] A severe neurological disorder marked by progressive dementia and cerebral cortical atrophy.

am (ăm; əm *when unstressed*) *v.* [ME < OE *eom*.] *1st person sing. present indicative of* BE.

Am *symbol for* AMERICIUM.

a·mah *also* **a·ma** (ä′mə, ă′mä) *n.* [Port. *ama*, nurse < Med. Lat. *amma*, mother.] An oriental maid, esp. a wet nurse.

a·main (ə-mān′) *adv. Archaic.* **1.** Strongly and intensely. **2.** Speedily or hastily. **3.** Greatly : exceedingly.

Am·a·lek·ite (ăm′ə-lĕk′īt′, ə-măl′ĭ-kīt′) *n.* [Heb. *Amālēqī*, after *Amālēq*, Amalek.] A member of an ancient nomadic tribe thought to be descended from Esau's grandson Amalek.

a·mal·gam (ə-măl′gəm) *n.* [ME < OFr. *amalgame* < Med. Lat. *amalgama*, prob. ult. < Gk. *malagma*, soft mass.] **1.** Any of various alloys of mercury and other metals, as with tin or silver. **2.** A combination of diverse elements : MIXTURE.

a·mal·ga·mate (ə-măl′gə-māt′) *v.* **-mat·ed, -mat·ing, -mates.** —*vt.* **1.** To mix so as to make a unified whole : BLEND. **2.** To mix or alloy (a metal) with mercury. —*vi.* **1.** To mix, unite, or consolidate. **2.** To unite or blend with another metal. —**a·mal′ga·ma′tive** *adj.* —**a·mal′ga·ma′tor** *n.*

a·mal·ga·ma·tion (ə-măl′gə-mā′shən) *n.* **1.** The act of amalgamating or condition of being amalgamated. **2.** A consolidation, as of several corporations. **3.** The dissolving of a metal in mercury to form an alloy.

a·man·dine (ä′mən-dēn′, ăm′ən-) *adj.* [Fr. < *amande*, almond < OFr. *almande*. —see ALMOND.] Made or garnished with almonds.

am·a·ni·ta (ăm′ə-nī′tə, -nē′-) *n.* [NLat. *Amanita*, genus name < Gk. *amanitai*, a fungus.] Any of various usu. highly toxic mushrooms of the genus *Amanita*.

a·man·ta·dine (ə-măn′tə-dēn′) *n.* [Alteration of E. *Adamantane*, a hydrocarbon + -INE².] An antiviral drug, $C_{10}H_{17}N{\cdot}HCl$, also used to treat Parkinson's disease.

a·man·u·en·sis (ə-măn′yo͞o-ĕn′sĭs) *n., pl.* **-ses** (-sēz′) [Lat. *amanuensis* < the phrase (*servus*) *a manu*, (slave) at handwriting.] A secretary employed to take dictation or copy manuscript.

am·a·ranth (ăm′ə-rănth′) *n.* [NLat. *Amaranthus*, genus name, alteration of Lat. *amarantus* < Gk. *amarantos*, unfading : *a-*, not + *marainein*, to wither.] **1.** A weedy plant of the genus *Amaranthus*, with small greenish or purplish flower clusters. **2.** An imaginary flower that never fades or dies. **3.** A deep reddish purple to dark or grayish purplish red. **4.** A dark red to purple azo dye.

am·a·ran·thine (ăm′ə-răn′thĭn, -thīn′) *adj.* **1.** Of, relating to, or like the amaranth. **2.** Lastingly beautiful : UNFADING. **3.** Deep purple.

am·a·relle (ăm′ə-rĕl′) *n.* [G. < Med. Lat. *amarellum* < Lat. *amarus*, bitter.] A variety of sour cherry with pale red fruit.

am·a·ret·to (ăm′ə-rĕt′ō) *n.* [Ital., dim. of *amaro*, bitter < Lat. *amarus*.] An almond-flavored liqueur.

am·a·ryl·lis (ăm′ə-rĭl′ĭs) *n.* [NLat. *Amaryllis*, genus name < Lat., name of a shepherdess < Gk. *Amarullis*.] **1.** A bulbous plant, *Amaryllis belladonna*, native to southern Africa, bearing large lilylike reddish or white flowers. **2.** Any of several similar or related plants. **3. Amaryllis.** A conventional name for a shepherdess in classical pastoral poetry.

a·mass (ə-măs′) *vt.* **a·massed, a·mass·ing, a·mass·es.** [OFr. *amasser* : *a-*, to (< Lat. *ad-*) + *masse*, mass.] **1.** To gather or pile up : COLLECT. **2.** To accumulate, esp. for profit or pleasure. —**a·mass′a·ble** *adj.* —**a·mass′er** *n.* —**a·mass′ment** *n.*

am·a·teur (ăm′ə-tûr′, -tər, -ə-cho͝or′, -chər, -tyo͝or′) *n.* [Fr. < Lat. *amator*, lover < *amare*, to love.] **1.** One who engages in an art, science, study, or athletic activity as a pastime rather than as a profession. **2.** An athlete who has never participated in competition for money or a livelihood. **3.** One lacking professional skill or ease in a given activity or area. —*adj.* **1.** Of, relating to, or performed by an amateur. **2.** Made up of amateurs. **3.** Unskillful or inexperienced. —**am′a·teur·ism** *n.*

★ ***syns:*** AMATEUR, DILETTANTE, NONPROFESSIONAL *n. core meaning* : one lacking professional skill and ease in a given activity or area <foreign policy mismanaged by *amateurs*> AMATEUR and NONPROFESSIONAL additionally refer to one who engages in an activity for enjoyment rather than money <golfers who are *amateurs*> <boxers who are *nonprofessionals*> , whereas DILETTANTE refers to one whose interest in an activity is merely superficial <a scholastic *dilettante*> ***ants:*** EXPERT, PROFESSIONAL

am·a·teur·ish (ăm′ə-tûr′ĭsh, -cho͝or′-, -tyo͝or′-) *adj.* Typical of an amateur. —**am′a·teur′ish·ly** *adv.* —**am′a·teur′ish·ness** *n.*

A·ma·ti (ä-mä′tē) *n.* A violin made by Nicolò Amati or the members of his family.

am·a·tive (ăm′ə-tĭv) *adj.* [Lat. *amare, amat-*, to love + -IVE.] Amatory. —**am′a·tive·ly** *adv.* —**am′a·tive·ness** *n.*

am·a·tol (ăm′ə-tôl′, -tŏl′) *n.* [< AM(MONIUM) + (TRINITRO)TOL(UENE).] A highly explosive mixture of ammonium nitrate and trinitrotoluene.

am·a·to·ry (ăm′ə-tôr′ē, -tōr′ē) *adj.* [Lat. *amatorius* < *amator*, lover < *amare*, to love.] Of, concerning, or promoting love, esp. sexual love.

am·au·ro·sis (ăm′ô-rō′sĭs) *n.* [Gk. *amaurōsis* < *amauros*, dark.] Total loss of vision : BLINDNESS. —**am′au·rot′ic** (-rŏt′ĭk) *adj.*

a·maze (ə-māz′) *vt.* **a·mazed, a·maz·ing, a·maz·es.** [ME **amasen* < OE *āmasian*, to confound.] **1.** To affect with surprise or great wonder : ASTONISH. **2.** *Obs.* To bewilder. —*n. Archaic.* Wonder. —**a·maz′ed·ly** (ə-mā′zĭd-lē) *adv.* —**a·maz′ed·ness** (-nĭs) *n.*

a·maze·ment (ə-māz′mənt) *n.* **1.** A state of extreme surprise or wonder : ASTONISHMENT. **2.** *Obs.* Bewilderment : perplexity.

Am·a·zon (ăm′ə-zŏn′, -zən) *n.* [ME < Lat. *Amazon* < Gk. *Amazōn*.] **1.** *Gk. Myth.* A member of a nation of female warriors alleged to have lived in Scythia near the Black Sea. **2.** *often* **amazon.** A tall, vigorous, strong-willed woman.

▲ ***word history:*** The Greeks themselves devised what is probably a folk etymology for *Amazon*. According to Greek legends the Amazons cut off their right breasts to be able to use a bow more easily. The word thus appears to be formed in Greek of the prefix *a-*, "not," and *mazos*, "breast," in reference to the Amazons' mutilated condition. This explanation, however, is probably not the correct one. It is more likely that the word *Amazon* is a Greek spelling of a non-Greek tribal name.

Am·a·zo·ni·an (ăm′ə-zō′nē-ən) *adj.* **1.** Typical of or like an Amazon. **2.** *often* **amazonian.** Vigorous and strong-willed. —Used of women.

am·a·zon·ite (ăm′ə-zə-nīt′) *n.* [After the *Amazon* River.] A green variety of microcline, often used as a semiprecious gemstone.

amazon stone *n.* Amazonite.

am·bage (ăm′bĭj) *n.* [Back-formation < ME *ambages*, equivocation < Lat. *ambages* : *ambi-*, around + *agere*, to drive.] *Archaic.* **1.** A circuitous pathway. **2.** *often* **ambages.** Roundabout ways. —**am·ba′gious** (ăm-bā′jəs) *adj.*

am·bas·sa·dor (ăm-băs′ə-dər,
ambassadeur < Med. Lat. *amba*
diplomatic official of the highest
resentative in residence by one g
ious diplomatic officials of th
large> **3.** A diplomatic official h
to an international organization,
thorized representative or mess
<an *ambassador* of good will>
-dôr′-) *adj.* —**am·bas′sa·do**

am·ber (ăm′bər) *n.* [ME *ambre*
bar, ambergris.] **1.** A hard, tran
yellow fossil resin, used for mal
2. A brownish yellow. —*adj.* B

am·ber·gris (ăm′bər-grĭs′, -g
bre, amber + *gris*, gray.] A wax
testines of sperm whales and fo
used in perfumery as a fixative.

am·ber·jack (ăm′bər-jăk′) *n.*
and game fish of the genus *Seri*
waters.

ambi– *pref.* [Lat., around.] Bot

am·bi·ance *also* **am·bi·en**
ambiant, surrounding < Lat. *a*
tive atmosphere surrounding or

am·bi·dex·ter·i·ty (ăm′bĭ-
of being ambidextrous. **2.** Hypo

am·bi·dex·trous (ăm′bĭ-dĕ
dealing < Med. Lat. : Lat. *amb*
handed.] **1.** Capable of using bo
tionally dexterous. **3.** Hypo
dex′trous·ly *adv.*

am·bi·ence (ăm′bē-əns, äN-b

am·bi·ent (ăm′bē-ənt) *adj.*
ambire, to surround : *ambi-*, a

am·bi·gu·i·ty (ăm′bĭ-gyo͞o′
state of being ambiguous. **2.** Sc

ambiguity error *n. Compu*
the readout of an electronic d
chronism, as in analog-to-digit

am·big·u·ous (ăm-bĭg′yo͞o-
ambigere, to go about : *ambi-*,
more than one interpretation.
ambiguous hue>

★ ***syns:*** AMBIGUOUS, CLO
SIBYLLINE, UNCERTAIN, UNCLEA
able to more than one interp
CLEAR, EXPLICIT

am·bi·po·lar (ăm′bĭ-pō′lər)
and negative ions in a plasma.

am·bit (ăm′bĭt) *n.* [Lat. *amb*
around. —see AMBIENT.] **1.** Th
or sphere : RANGE.

am·bi·tion (ăm-bĭsh′ən) *n.*
ambitio < *ambire*, to go arou
eager or strong desire to achie
sired. **2.** A desire for exertion o
ambition.>

★ ***syns:*** AMBITION, DRIVE,
meaning : the wish, power, an
a plan or task <young execut

am·bi·tious (ăm-bĭsh′əs) *a*
ambition. **2.** Greatly desirou
CHALLENGING. —**am·bi′tio**

am·biv·a·lence (ăm-bĭv′ə-
both sides + Lat. *valens*, bein
existence of mutually conflic
son, object, or idea. **2.** Uncer
DECISION.

am·biv·a·lent (ăm-bĭv′ə-l

am·bi·ver·sion (ăm′bĭ-vû
SION or (EXTRO)VERSION.] A pe
and extroversion. —**am′bi·**

am·ble (ăm′bəl) *vi.* **-bled, -**
bler < Lat. *ambulare*, to wal
proceed smoothly by lifting f
on the other, as do horses. —*n*
2. A leisurely pace : SAUNTER

am·blyg·o·nite (ăm-blĭg′
blugōnios, obtuse-angled : *an*
greenish mineral, (Li,Na)Al(F

am·bly·o·pi·a (ăm′blē-ō′
dim-sighted : *amblus*, dim.

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Materials

Accuflect

Aluminum Nitride

Aluminum Oxide

Boron Nitride

Fused Silica

Macor

Mullite

Sialon

Silicon Carbide

Silicon Nitride

Zirconium Oxide

Aluminum Oxide, Al_2O_3

Alumina is the most cost effective and widely used material in the family of engineering ceramics. The raw materials from which this high performance technical grade ceramic is made are readily available and reasonably priced, resulting in good value for the cost in fabricated alumina shapes. With an excellent combination of properties and an attractive price, it is no surprise that fine grain technical grade alumina has a very wide range of applications.

.Key Properties

- Hard, wear-resistant
- Excellent dielectric properties from DC to GHz frequencies
- Resists strong acid and alkali attack at elevated temperatures
- Good thermal conductivity
- Excellent size and shape capability
- High strength and stiffness
- Available in purity ranges from 94%, an easily metallizable composition, to 99.5% for the most demanding high temperature applications.

Typical Uses

- Gas laser tubes
- Wear pads
- Seal rings
- High temperature electrical insulators

- High voltage insulators
- Furnace liner tubes
- Thread and wire guides
- Electronic substrates
- Ballistic armor
- Abrasion resistant tube and elbow liners
- Thermometry sensors
- Laboratory instrument tubes and sample holders
- Instrumentation parts for thermal property test machines
- Grinding media

General Information

Aluminum oxide, commonly referred to as alumina, possesses strong ionic interatomic bonding giving rise to it's desirable material characteristics. It can exist in several crystalline phases which all revert to the most stable hexagonal alpha phase at elevated temperatures. This is the phase of particular interest for structural applications and the material available from Accuratus.

Alpha phase alumina is the strongest and stiffest of the oxide ceramics. Its high hardness, excellent dielectric properties, refractoriness and good thermal properties make it the material of choice for a wide range of applications.

High purity alumina is usable in both oxidizing and reducing atmospheres to 1925°C. Weight loss in vacuum ranges from 10^{-7} to 10^{-6} g/cm^2.sec over a temperature range of 1700° to 2000°C. It resists attack by all gases except wet fluorine and is resistant to all common reagents except hydrofluoric acid and phosphoric acid. Elevated temperature attack occurs in the presence of alkali metal vapors particularly at lower purity levels.

The composition of the ceramic body can be changed to enhance particular desirable material characteristics. An example would be additions of chrome oxide or manganese oxide to improve hardness and change color. Other additions can be made to improve the ease and consistency of metal films fired to the ceramic for subsequent brazed and soldered assembly.

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Engineering Properties*

94% Aluminum Oxide

Mechanical	Units of Measure	SI/Metric	(Imperial)
Density	gm/cc (lb/ft^3)	3.69	(230.4)
Porosity	% (%)	0	(0)
Color	—	white	—
Flexural Strength	MPa (lb/in^{2}x10^3)	330	(47)
Elastic Modulus	GPa (lb/in^{2}x10^6)	300	(43.5)
Shear Modulus	GPa (lb/in^{2}x10^6)	124	(18)
Bulk Modulus	GPa (lb/in^{2}x10^6)	165	(24)
Poisson's Ratio	—	0.21	(0.21)
Compressive Strength	MPa (lb/in^{2}x10^3)	2100	(304.5)
Hardness	Kg/mm^2	1175	—
Fracture Toughness K_{IC}	MPa•m$^{1/2}$	3.5	—
Maximum Use Temperature (no load)	°C (°F)	1700	(3090)
Thermal			
Thermal Conductivity	W/m•°K (BTU•in/ft^2•hr•°F)	18	(125)
Coefficient of Thermal Expansion	10^{-6}/°C (10^{-6}/°F)	8.1	(4.5)
Specific Heat	J/Kg•°K (Btu/lb•°F)	880	(0.21)
Electrical			
Dielectric Strength	ac-kv/mm (volts/mil)	16.7	(418)
Dielectric Constant	@ 1 MHz	9.1	(9.1)
Dissipation Factor	@ 1 kHz	0.0007	(0.0007)
Loss Tangent	@ 1 kHz	—	—

Volume Resistivity	ohm•cm	$>10^{14}$	—

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96% Aluminum Oxide

Mechanical	**Units of Measure**	**SI/Metric**	**(Imperial)**
Density	gm/cc (lb/ft^3)	3.72	(232.2)
Porosity	% (%)	0	(0)
Color	—	white	—
Flexural Strength	MPa ($lb/in^2 x 10^3$)	345	(50)
Elastic Modulus	GPa ($lb/in^2 x 10^6$)	300	(43.5)
Shear Modulus	GPa ($lb/in^2 x 10^6$)	124	(18)
Bulk Modulus	GPa ($lb/in^2 x 10^6$)	172	(25)
Poisson's Ratio	—	0.21	(0.21)
Compressive Strength	MPa ($lb/in^2 x 10^3$)	2100	(304.5)
Hardness	Kg/mm^2	1100	—
Fracture Toughness K_{IC}	MPa•$m^{1/2}$	3.5	—
Maximum Use Temperature (no load)	°C (°F)	1700	(3090)
Thermal			
Thermal Conductivity	W/m•°K (BTU•in/ft^2•hr•°F)	25	(174)
Coefficient of Thermal Expansion	10^{-6}/°C (10^{-6}/°F)	8.2	(4.6)
Specific Heat	J/Kg•°K (Btu/lb•°F)	880	(0.21)
Electrical			
Dielectric Strength	ac-kv/mm (volts/mil)	14.6	(365)
Dielectric Constant	@ 1 MHz	9.0	(9.0)
Dissipation Factor	@ 1 kHz	0.0011	(0.0011)
Loss Tangent	@ 1 kHz	—	—
Volume Resistivity	ohm•cm	$>10^{14}$	—

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99.5% Aluminum Oxide

Mechanical	Units of Measure	SI/Metric	(Imperial)
Density	gm/cc (lb/ft^3)	3.89	(242.8)
Porosity	% (%)	0	(0)
Color	—	ivory	—
Flexural Strength	MPa ($lb/in^2 x 10^3$)	379	(55)
Elastic Modulus	GPa ($lb/in^2 x 10^6$)	375	(54.4)
Shear Modulus	GPa ($lb/in^2 x 10^6$)	152	(22)
Bulk Modulus	GPa ($lb/in^2 x 10^6$)	228	(33)
Poisson's Ratio	—	0.22	(0.22)
Compressive Strength	MPa ($lb/in^2 x 10^3$)	2600	(377)
Hardness	Kg/mm^2	1440	—
Fracture Toughness K_{IC}	MPa•$m^{1/2}$	4	—
Maximum Use Temperature (no load)	°C (°F)	1750	(3180)
Thermal			
Thermal Conductivity	W/m°K (BTU•in/ft^2•hr•°F)	35	(243)
Coefficient of Thermal Expansion	10^{-6}/°C (10^{-6}/°F)	8.4	(4.7)
Specific Heat	J/Kg•°K (Btu/lb•°F)	880	(0.21)
Electrical			
Dielectric Strength	ac-kv/mm (volts/mil)	16.9	(420)
Dielectric Constant	@ 1 MHz	9.8	(9.8)
Dissipation Factor	@ 1 kHz	0.0002	(0.0002)
Loss Tangent	@ 1 kHz	—	—
Volume Resistivity	ohm•cm	$>10^{14}$	—

*All properties are room temperature values except as noted.
The data presented is typical of commercially available material and is offered for comparative purposes only. The information is not

to be interpreted as absolute material properties nor does it constitute a representation or warranty for which we assume legal liability. User shall determine suitability of the material for the intended use and assumes all risk and liability whatsoever in connection therewith.

See also: Ceramic Rod & Tube
See also: Ceramic Rod & Tube > Available Aluminum Oxide Sizes

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